Management of Wastewater from Car Wash sites using locally sourced Natural Coagulants and simple Filtration Process

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Abstract- With the increasing car wash businesses in urban areas and cities in Nigeria, there is an increase in the volume of wastewater generated from these carwash sites. These wastewaters contribute to environmental pollution as they often found themselves flowing into the environment without any control or modifications. This study aimed to develop a simple and efficient treatment process for carwash wastewater based on coagulation and flocculation using natural coagulants namely C*arica papaya* dried seeds and Aluminium sulphate ($Al_2(SO_4)_3$,$18H_2O$) in addition to a natural filtration system. The carwash wastewater samples were collected from different carwash sites located at Asaba, Delta State Nigeria. The management of the wastewater samples was planned prototype incorporating four phases namely: aeration, coagulation plus flocculation, sedimentation and filtration. The study examined the efficiency of the designed wastewater management and treatment system using different dosage (35, 70, and 140 mg L^{-1}) of *Carica papaya* and Aluminium sulphate ($Al_2(SO_4)_3$,$18H_2O$) respectively in the coagulation plus flocculation phase. The pretreated and post treated car wash wastewaters were analyzed for values of pH, dissolved oxygen (DO), chemical oxygen demand (COD) and turbidity (NTU). Values obtained for the post treated car wash wastewaters indicate that the designed treatment system was effective for primary treatment of raw carwash wastewater. The treated carwash wastewaters meet National Environmental Standards and Regulations Enforcement Agency (NESREA) requirements National Environmental Standards and Regulations Enforcement Agency (NESREA). Adoption of this process for waste water treatment is recommended as this would help reduce environmental pollution resulting from carwash wastewaters and save water for reuse in the small scale car washing enterprises in Nigeria .

Index Terms- natural **c**oagulants, flocculation, filtration, sedimentation, *carica papaya*, environmental pollution

I. Introduction

Environmental pollution due to wastewaters from industrial and commercially related activities in cities in Nigeria is increasing every day. Carwash wastewater is a potential environmental pollutant due to the plausible presence all types of dirt, oil, grease, heavy metals and chemicals from soaps and cleaning agents used in car washes (Tekere et al., 2016). In Nigeria, at the moment, most of the car washes sites do not have any treatment plant or system for the wastewater generated from their businesses. The car wastewaters are often directly into the roadsides or into sewage or gutters running to the streets or nearby streams and rivers.

Most of the services in the urban areas requiring use of water and generating wastewaters are small and medium scale enterprises such as the local car wash stands common in Nigerian cities. These car washes are often manually operated with boys washing the cars and rinsing them directly from buckets and plastic containers with water and detergents. The cost of obtaining clean and usable water for washing and doing commercially activities often lead to the hike in prices of such water demanding services.

The Nigerian government in the year 1988 established the Federal Environmental Protection Agency (FEPA) through decree 58 of December 1988 (Omofonmwan & Osa-Edoh, 2008). This Agency later metamorphosed into the Federal Ministry of Environment (FMENV) in 1999. FMENV duties included formulation of national environmental guidelines, standards, and criteria, specifically in the areas of water quality, effluent discharge, air and atmospheric quality. In Nigeria, the car wash industry is not properly monitored or regulated yet. For example, the disposal of car wastewater is not monitored or regulated. Later in 2007, the federal government established the National Environmental Standards and Regulations Enforcement Agency (NESREA). This Agency is saddled with the responsibility to enforce environmentally related laws and ensure compliances to environmental regulations and guidelines (Suleiman et al., 2019).

The wastewaters generated from car washes often have high turbidity due to the presence of dissolved substances of various natures. Treatment of wastewater has inherent advantages. These include the reduction of possible environmental pollution impacts of the wastewater. Secondly, a simple water treatment process can ensure there is recycling of the water making good quality water available for use gain.

There is increasing interest in the use of natural coagulants in the development of water treatment systems especially in the coagulation and flocculation phases. The shift in paradigm use is connected with noted environmental and health complications arising from the use of synthetic flocculants and coagulants such

as ferric chloride and ferric chloride sulphate. Most of the chemicals used in waste water treatments are expensive and also sometimes carcinogenic and harmful to human health. Hence, the use of natural coagulants provides a cheaper and safer alternative to synthetic or artificial coagulants and flocculants (García-Fayos et al.,2018; Ang & Mohammad, 2020).

In a similar study, Radin et al (2014) investigated the efficiency of Drumstick tree (*Moringa oleifera)* seeds and clearing-nut tree *(Strychnos potatorum)* seeds as natural coagulants compared with some artificial common coagulants in the treatment of car wash wastewater. The findings indicated that both plants seeds contain coagulating substances that can improve water quality of waste or contaminated water. These were seen in the changes in turbidity, *chemical oxygen demand* (COD), *Biochemical oxygen demand* (BOD) and *Total suspended solids* (TSS) values of the wastewaters treated with these natural coagulants.

The present study adopts with some little modifications the treatment process of car wash wastewater by Mohamed, et al (2014). The waste water treatment phases consist of the aeration, coagulation and flocculation, sedimentation and filtration. The coagulant used was *Carica Papaya seeds* and Aluminium sulphate ($Al_2(SO_4)_3$,$18H_2O$). The target was to ensure that the treated water meets environmentally friendly standards as approved by the National Environmental Standards and Regulations Enforcement Agency (NESREA) requirements for effluents. The water parameters namely pH, dissolved oxygen (DO), chemical oxygen demand (COD) and turbidity (NTU) were assessed and monitored both at the pretreated and post treated phases.

Material and Methods

Collection of carwash wastewater samples

The wastewater samples were collected from selected six busy car wash sites spread across Asaba capital city in Delta State Nigeria. The collection was done in the month of June 2020. The samples were taken using grab sampling technique into the plastic bottles (2 L) and transported to the laboratory for analysis (APHA, 2005).

Standard laboratory analysis procedures according to APHA (2005) were used to analyze the water samples. Included were test for pH, Turbidity, Chemical Oxygen Demand (COD), and Dissolved Oxygen (DO). COD were determined using Reactor Digestion Method (Method 8000, HACH DR 6000), the DO was tested using DO meter (EC Probe Meter), the pH, using a calibrated pH meter (EC Probe Meter) and the turbidity was done by Attenuated Radiation Method (Method 3750, HACH DR 6000).

Preparation of Carica papaya seeds and Aluminium sulphate

Carica papaya fruits were purchased from a local market and the seeds were dried under the sunlight. The seeds were grounded into fine particles and dried at 100˚C for 24 hrs. With the aid of a blender, the dried seeds were further milled into fine powder and then sieved through a 50-mesh sieve according to coagulant-method (Suhartini et al., 2013). The chemical Aluminium sulphate ($Al_2(SO_4)_3$,$18H_2O$ salts (CAS:7782-63-0, Fisher Scientific) was purchased and used as synthetic coagulant.

Scheme of simple filtration based treatment system

The treatment system was designed as shown in the scheme below. It consists of four phases which comprise aeration, coagulation and flocculation unit, sedimentation and filtration unit.

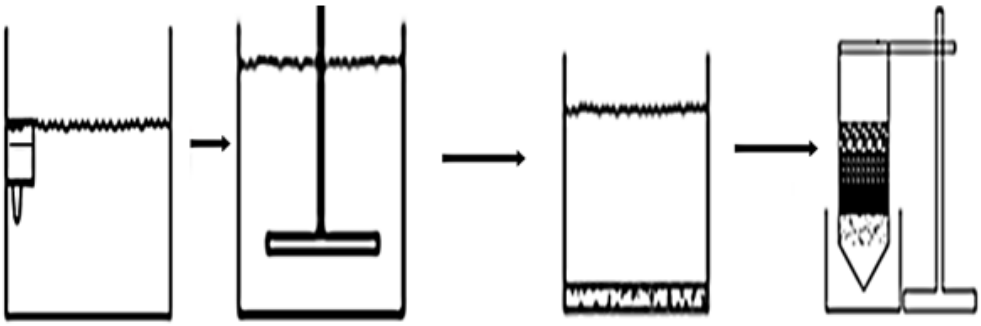

Figure 1: Schematic representation car wash wastewater treatment process

The scheme protocol involves putting, a volume of one litre of wastewater sample transported manually into the aeration tank (30cm×20cm×18cm), and aerated for 30 min. The wastewater was pumped into the flocculation and coagulation tank using a water pump. The flocculation and coagulation chamber was made of transparent bottle container (14cm×20cm×14cm) connected to a Direct Current motor (DC Geared Motor, DC12V) with 1.1 watt, 103 rpm, 410 mA, 127.4 mN and 8 mm of shaft diameter.

The wastewater sample was mixed with 15 mg of prepared *carica papaya* powder was added into the flocculation and coagulation chamber for one hour. Next, the supernatant was pumped slowly into sedimentation chamber and allowed to settle for one hour. The supernatant was obtained from the natural filtration chamber comprising sand and gravel.

The same treatment process was repeated with different doses of *Carica papaya* and Aluminium sulphate ($Al_2(SO_4)_3$,$18H_2O$). (35, 70 and 140 mg, respectively). The pH, turbidity, DO and COD of treated car wash wastewaters were analyzed.

II. Results and Discussion

The mean of pH, turbidity, DO and COD of raw car wash wastewater are illustrated in Table 1.

Table 1. Parameters of raw carwash wastewater samples.

Parameter	Unit	Values obtained for Raw car wash wastewater	Effluent discharge Permissible levels by Nigerian NESREA standards
pH	-	6.95	6-9
Turbidity	(NTU)	170.1 ± 1.9	5
Dissolved Oxygen (DO)	(mg /L)	2.55	5
Chemical Oxygen Demand (COD)	(mg /L)	220	60
Oil and grease	(mg/L)	13	10

Car wash wastewater generated usually contains detergents, shampoo and diesel, and materials that usually contribute to making it very turbid. The sample turbidity, DO and COD were higher than the effluent discharge Permissible levels by Nigerian NESREA standards (2011).

While, pH was within the international standards limits. These results are in agreement with those reported in similar studies on treatment of car wash effluents conducted in Malaysia and in India (Lau et al., 2013; Mazumder & Mukherjee, 2011). However, they were differed from that reported in a related study by Radin et al., 2014).

The increasing the turbidity of wastewater indicated can be an indication that the wastewater has high concentrations of total suspended solid (TSS (Sarmadi et al., 2020). High TSS values are usually due to presence of dirt particles from washed cars and vehicles which is a reflection of the type of dust and mud particles in the environment.

The high COD values might be related to the presence of soap or detergents used in the car wash sites. These detergents can cause oxidation process of organic compounds resulting in high COD of the sample waters (Ahmad et al., 2019).

Generally, it is seen that the parameters of raw carwash wastewaters are higher than the effluent discharge permissible levels by Nigerian NESREA standards (2011). Consequently, these wastes need to be treated to improve their characteristics and prevent resultant pollution from their discharge into the environment.

Efficiency of coagulant integrated filtration treatment

The efficiency of the integrated treatment system design here for treating of carwash wastewater was evaluated based on pH, turbidity, DO and COD. The characteristics of wastewater treated with different doses of *Carica papaya* and $Al_2(SO_4)_3$,$18H_2O$ are presented in Table 2.

Table 2. Characteristics of carwash wastewater treated with different doses of *Carica papaya seed powder* and ($Al_2(SO_4)_3$ $18H_2O$

Coagulant dose (mg L^{-1})	pH		Turbidity (NTU)		DO (mg L^{-1})		COD (mg L^{-1})	
	Carica papaya	($Al_2(SO_4)_3$, $18H_2O$	*Carica papaya seed*	($Al_2(SO_4)_3$, $18H_2O$	*Carica papaya seed*	($Al_2(SO_4)_3$, $18H_2O$	*Carica papaya seed*	($Al_2(SO_4)_3$, $18H_2O$
0	6.95		274.0		2.40		220	
35	6.80	5.25	39.7	47.7	4.19	3.6	215	217
70	7.05	4.83	23.4	30.7	5.86	4.90	195	205
140	6.17	3.85	8.35	17.5	7.15	6.35	141	165
NESREA standards (2011)	6-9		5		5		60	

Dissolved Oxygen (DO); Chemical Oxygen Demand (COD). NESREA (2011).

It can be noted that pH, and DO of treated wastewater reduced to meet Nigerian NESREA (2011) standards for effluents. The maximum value of pH was recorded with 70 mg L^{-1} of *Carica papaya*. In contrast, pH was decreased with increasing amounts of $Al_2(SO_4)_3$,$18H_2O$ to pH 3.85 at a dose 140 mg L^{-1}. These results indicated that the natural coagulant is more efficient to adjust pH value of wastewater than chemical coagulant ones. These findings

were similar to that recorded by Radin et al., (2014). However, in that study the author reported that the alum and Ferric sulphate used as coagulant was better as coagulant because little or no further addition of chemical would be required to correct the finished water pH. Conversely, this study demonstrated that *Carica papaya* is the better coagulant because the pH value still within the standards limits 6-9 even at high concentrations.

Carica papaya seed as a coagulant caused increased car wash wastewater DO from 2.40 to 7.15 mg L^{-1} at a dose of 140 mg L^{-1}, while Aluminium sulphate ($Al_2(SO_4)_3.18H_2O$) increased it to 6.35 at same concentrations.

Both coagulants were effective for reducing turbidity from 274.0 NTU to 8.35 and 17.5 mg L^{-1}NTU respectively at 140 mg L^{-1} of concentrations. The values obtained for turbidity of the car wash wastewaters however remained higher than Permissible levels for effluent discharge by Nigerian NESREA standards (2011). However, the wastewater treated with *Carica papaya* was almost near to meet the standards limits (5 NTU).

The results showed that the coagulation of wastewater with *Carica papaya* reduced turbidity by approximately 97% (from 274.0 to 8.35 NTU). With 140 mg L^{-1} coagulant dose, the COD exhibited less response for both coagulant substrates. The COD values reduced from 220 mg L^{-1} to 141 and 165 mg L^{-1} due to effects of *Carica papaya* and Aluminium sulphate ($Al_2(SO_4)_3.18H_2O$) respectively. However, the car wash wastewater meets the regulations required NESREA (2011) standards for effluents.

In general, *Carica papaya* was more effective in the treatment of raw carwash of pollutants than Aluminium sulphate ($Al_2(SO_4)_3,18H_2O$) at different concentrations investigated in this study. This result might be related to nature of *Carica papaya* as adsorbent for H^+ ions. Natural adsorbents do display the ability of neutralization of solution. Thus, the turbidity in the wastewater treated with carica papaya seed *was* less than that treated with Aluminium sulphate ($Al_2(SO_4)_3.18H_2O$). An obvious advantage of the use of *Carica papaya* compared to Aluminium sulphate $Al_2(SO_4)_3,18H_2O$ is that it can be locally sources from farms and gardens in Nigeria. It is cheap to get and the seeds are usually discarded by most people who consume *carica papaya* fruit.

III. Conclusion

The study shows that *Carica papaya* was effective as coagulant for treatment of raw car washes wastewater. The wastewater treated with low concentrations of *Carica papaya* meet the regulation required in NESREA guidelines in the terms of pH and DO permissible values for effluents. The reduction of turbidity and COD also satisfied NESREA guidelines. In general, the noted parameters of treated car wash wastewaters in the study makes the output waters suitable for washing and other domestic purposes. The assessment of the car wash wastewaters from the selected sites revealed instances of non-compliance with NESREA guidelines for effluents. There is need for effective monitoring of industrial wastewater discharges from car wash businesses in Nigeria by relevant regulatory bodies to ensure compliance with set environmental standards for effluents that can negatively impact the environment..

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